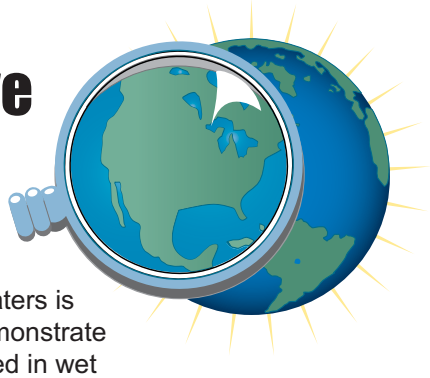
How can we tell if other planets have water?



Investigation Overview

Students learn that the presence of craters is an indication of a dry planet. They demonstrate how craters are concealed or obliterated in wet climates. Students also use satellite images to assess the presence of water on two other planets.

Time required: Two 45-minute sessions

Materials/Resources

NASA images (transparencies of each)
- Figure 1: The planets in our solar system
- Figure 2: Craters on Mercury
- Figure 3: Mars
- Figure 4: Earth
- Figure 5: Chesapeake Bay
- Figure 6: Mars in 1977
- Figure 7: Mars in 2000

Two trays with at least a 2 inch deep lip
Damp sand
About 30 marbles
Log 1: Our experiment
Log 2: The Chesapeake Bay crater
United States map (showing Chesapeake Bay)

Content Preview

A crater is a saucer-shaped pit or depression on a planetary surface. Craters are formed by the impact of meteorites and asteroids, pieces of space debris that strike a planet or other body. Erosion obscures and destroys most of the craters on Earth.

Classroom Procedures

Beginning the Investigation

1. Project a transparency of **Figure 1**. Have students name the planets and tell or write what they know about them. Talk about similarities and differences among and between the planets, distance from the Sun, vegetation, water availability, etc. A student or the educator should record the comments.

Developing the Investigation

Craters and Water

2. Project transparencies of **Figures 2** and **3**. **Figure 2** is Mercury, and **Figure 3** is Mars. Brainstorm about the surfaces of these planets while looking at the NASA images. Have students point out the craters by

Geography Standards

Standard 1: The World in Spatial Terms

How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

- Identify and describe the characteristics and purposes of geographic representations.

Standard 4: Places and Regions

The physical and human characteristics of places

- Describe and compare the physical characteristics of places.

Standard 7: Physical Systems

The physical processes that shape the patterns of Earth's surface

- Explain how physical processes help to shape features and patterns on Earth's surface.

Geography Skills

Skill Set 2: Acquire Geographic Information

- Make and record observations about the physical and human characteristics of places.

Skill Set 4: Analyze Geographic Information

- Use texts, photographs, and documents to observe and interpret geographic trends and relationships.

marking them on the overhead. Ask the students to define "crater."

Crater: A saucer-shaped pit or depression on a planetary surface.

3. Ask the following questions and list the students' responses on the chalkboard.

   - What causes craters? (*The impacts of meteorites and asteroids create craters. Scientists can determine the relative age of the surface of the Moon by the number of craters.*)
   - Why does Earth have so few visible craters compared to the Moon and some other planets? Is it because Earth is struck less often? (*No, it is because on the other bodies there is little or no water to obscure or destroy the craters.*) Meteorites may disintegrate in Earth's atmosphere.

   Project **Figure 4** of Earth. Look for signs of craters.

   - How would water cover up or destroy craters? (*Rain, flowing water, and moving ice erode them and/or fill them with sediment. And where there is moisture there may also be vegetation, which can obscure craters. Other erosion processes such as wind erosion or plate tectonics also change the shape of the Earth's surface.) If asteroids or meteors strike large water bodies, no crater would be formed.*

4. Do the following experiment to show how a planet's surface is impacted by meteors.

   A. Place two sand trays filled with damp sand on the floor, with sand surface smoothed. Label the trays 1 (older) and 2 (newer). Have students drop a marble every 10 seconds into Tray 1. Each drop will create a crater. Continue the experiment for four minutes with Tray 1, and for two minutes with Tray 2. Carefully remove the marbles to expose the craters. Explain that when meteorites strike a planet, they land with such force that they usually disintegrate. Have the students count the number of craters in each tray. The "old" four-minute tray will have more craters. This illustrates the idea that, when craters persist, scientists can use their number to determine the relative age of the surface. Follow up by identifying older and younger sections of Martian crust in **Figure 3**, with obvious differences in the number of craters. The newer crust is generally the result of lava flows.

   B. Take the older, four-minute tray (Tray 1) and gently sprinkle water on it. The craters will soon be worn away. This illustrates the effect of water—rain, rivers, waves, etc. in wearing away evidence of craters on Earth.

   C. Smooth out the other sand tray (Tray 2), and form a hole or depression in the middle. Fill the depression with water. Have students drop marbles on the sand and in the water. This will illustrate how an impact in the oceans is much less likely to leave a crater than one on land. Thus, an ocean-covered planet will have fewer craters.

5. Have students write about their experiment and findings on **Log 1** and share their responses.

6. Show a transparency of **Figure 5** and ask a student to read **Log 2** about the Chesapeake Bay bolide crater. Share additional information from **Background** on the Chesapeake Bay crater.

7. Find the location of the impact site on a map showing the Chesapeake Bay area and circle the site on the transparency. (The site is under the southern part of the bay. The narrow extension of the peninsula to the east of the bay covers part of the crater. The peninsula formed from sediments deposited over the crater.) Tell the students that NASA Langley Research Center in Hampton, Virginia, sits on the edge of this 30 kilometer wide impact crater. (Hampton is marked by a red dot in the image.)

8. Return to a sand tray and create a sloping valley. Add water to make a river and watch the flow of water. Make a crater by dropping a large ball of clay onto the river. Carefully remove the ball of clay. Add more water and predict what will happen. (*The river will fill the crater.*)

Concluding the Investigation

9. Tell the class that NASA's increasing ability to explore outer space is rapidly providing new information about other planets. When Mars was visible only by telescopes, the most easily distinguished features were large craters. Therefore, it was assumed that the planet had always been very dry. In 1977, NASA's Viking Orbiter spacecraft reached Mars and sent back images that showed large canyons similar to the canyons formed by water on Earth. That made scientists think that Mars may have had a great deal of water on its surface in its ancient past. But until recently,

detailed images of Mars' surface were not available to search for more evidence of water.

10. Show the students the transparency of **Figure 6** and explain that this is one of the Viking Orbiter images. Ask them to find the canyons and have one of the students mark several of them on the transparency. Ask how many craters the students can see and have another student circle some of them. Point out the small white square in the image and explain that this marks the area that the class will see close up. Note that one of the canyons runs through this square.

11. Explain that the Mars Global Surveyor spacecraft has been in orbit over Mars since 1997, and that in its first three years in orbit it produced over 80,000 detailed images of the planet's surface. Show **Figure 7** and tell the class that this is an image from Surveyor of the area inside the square in the previous image.

12. Ask if the students can figure out what they are looking at. Explain that this is the side of the canyon. The top of the image shows relatively flat land. The irregular band from left to right shows the top of the cliff that forms one side of the canyon. Under the top of the cliff is a dark band, which is a shadow made by overhanging rock. In this area, water has seeped out and eroded the rock below it, making the cliff recede and creating gullies down the slope. Ask the students if they can see the gullies.

13. Have one student draw a line on the transparency along the top of the cliff. Ask the class to use the scale on the image and figure out how far below the top of the cliff the water seeped out. (*About 100 meters.*) Have another student make a circle around one of the gullies. Ask the class to estimate the length of the gullies. (*100–200 meters.*)

14. Explain that the most interesting thing about this erosion is that it is so recent that it is probably still going on. Scientists can tell by their appearance that the gullies were formed within the last few decades. This tells us that enough water has been seeping out onto parts of Mars' surface in recent years to erode the land. Mars is not as dry as we once thought!

Background

Liquid water is a rare commodity in our solar system. Only on a planet of the right mass and chemical composition, and the right distance from a neighboring star, can liquid water be found. As far as we know, Earth is the only planet in our solar system that has large water bodies. Some other planets have significant amounts of frozen water. Jupiter's moons appear to have liquid water that is trapped under thick surface ice. On Mars underground water appears to seep out onto the surface in places, but it apparently vaporizes before it can accumulate.

Planets can be struck by comets or asteroids (also called bolides). The depressions made by the impact can fill up with water to make lakes or bays. The Chesapeake Bay bolide helped to create the Chesapeake Bay.

Background: Chesapeake Bay Crater

A spectacular geological event took place on the Atlantic margin of North America about 35 million years ago. Sea level was unusually high everywhere on Earth, and the ancient shoreline of the Virginia region was somewhere in the vicinity of where Richmond is today. Tropical rain forests covered the slopes of the Appalachians.

Suddenly, with an intense flash of light, from the far reaches of space, a bolide (comet or asteroid), 3–5 kilometers in diameter, swooped through the atmosphere and struck Earth, creating an enormous crater approximately 200 kilometers southeast of Washington, D.C. It is buried 300–500 meters beneath the southern part of Chesapeake Bay and the southern part of the Delmarva Peninsula (which developed after the crater was formed).

The Chesapeake Bay crater was recently identified by the U.S. Geological Survey (USGS), which has assembled an international team to investigate its characteristics. Evidence of the crater comes from two sources: (1) cores drilled by the USGS and the Virginia State Water Control Board and (2) marine seismic-reflection profiles collected by Texaco, Inc., the USGS, and the National Geographic Society.

Analysis of the profiles shows that the crater is 85 kilometers in diameter and 1.3 kilometers deep, an excavation twice the size of Rhode Island and as deep as the Grand Canyon. It is three times larger than any other U.S. crater and is the sixth largest known crater on the planet. A rubble bed fills the crater and forms a thin halo around it.

Discovery of the giant crater has completely revised our understanding of Atlantic Coastal Plain evolution. Several consequences of the ancient cataclysm still affect the land around Chesapeake Bay today: land subsidence, river diversion, disruption of coastal aquifers, and ground instability. (See http://marine.usgs.gov/fact-sheets/fs49-98/ for more information.)

Evaluation

Log 1

1. A round depression on the surface of a planet
2. Asteroids, comets, or meteors collide with a planet
3. Answers will vary
4. Answers will vary
5. Mercury, Mars, Earth
6. They have been covered by water and vegetation, eroded away, buried under sediment.

Additional Resources

http://www.ess.ucla.edu/hypermap/Vmap/top.html
http://mars3.jpl.nasa.gov/mgs/realtime/groupd-pds.html
Shows real-time images with good contrast
http://spaceart.com/solar. Links to other sites. Planetary images including satellite and close-ups showing cratered and noncratered surfaces
http://nssdc.gsfc.nasa.gov/image/planetary/moon/gal_moon_color.jpg. A good shot of the Moon
Venus, http://spaceart.com/solar/raw/venus/venus.gif Doesn't show craters well due to Venus' thick atmosphere. Does show how an oceanless planet looks very different.
http://pds.jpt.nasa.gov/planets/gif/ven/golubnew.gif Venus's surface
www.challenger.org - Challenger Center classroom programs, Mars City
CD-ROM, *Visit to an Ocean Planet*, NASA educational product
Poster of Solar System, NASA educational product
Solar System Lithography Set for Space Science, NASA educational product

Module 2, Investigation 2: Log 1

Our experiment

Dear Family:
We did a very interesting experiment about craters today.

1. A crater is _____

_____

_____

2. Here is what causes craters.

_____

_____

_____

3. Here are two drawings of craters.

Module 2, Investigation 2: Log 1

Our experiment

4. This is the experiment that we did to demonstrate what causes craters. Here are three pictures and sentences telling you what we did.

A.

A. _____

_____

_____

B.

B. _____

_____

_____

C.

C. _____

_____

_____

5. We looked at images of these planets.

_____ _____

_____

6. We cannot see as many craters on the surface of Earth because

_____

_____

Module 2, Investigation 2: Log 2

The Chesapeake Bay crater

What is the smallest state in the area? (Rhode Island)

Double the state's size and you have the area that we are talking about.

What is the deepest canyon in the United States? (Grand Canyon)

Now you have it . . . an area twice the size of Rhode Island and as deep as the Grand Canyon. What is it and where is it?

It is the giant crater caused by a spectacular event that happened where the Chesapeake Bay is located today. It happened about 35 million years ago.

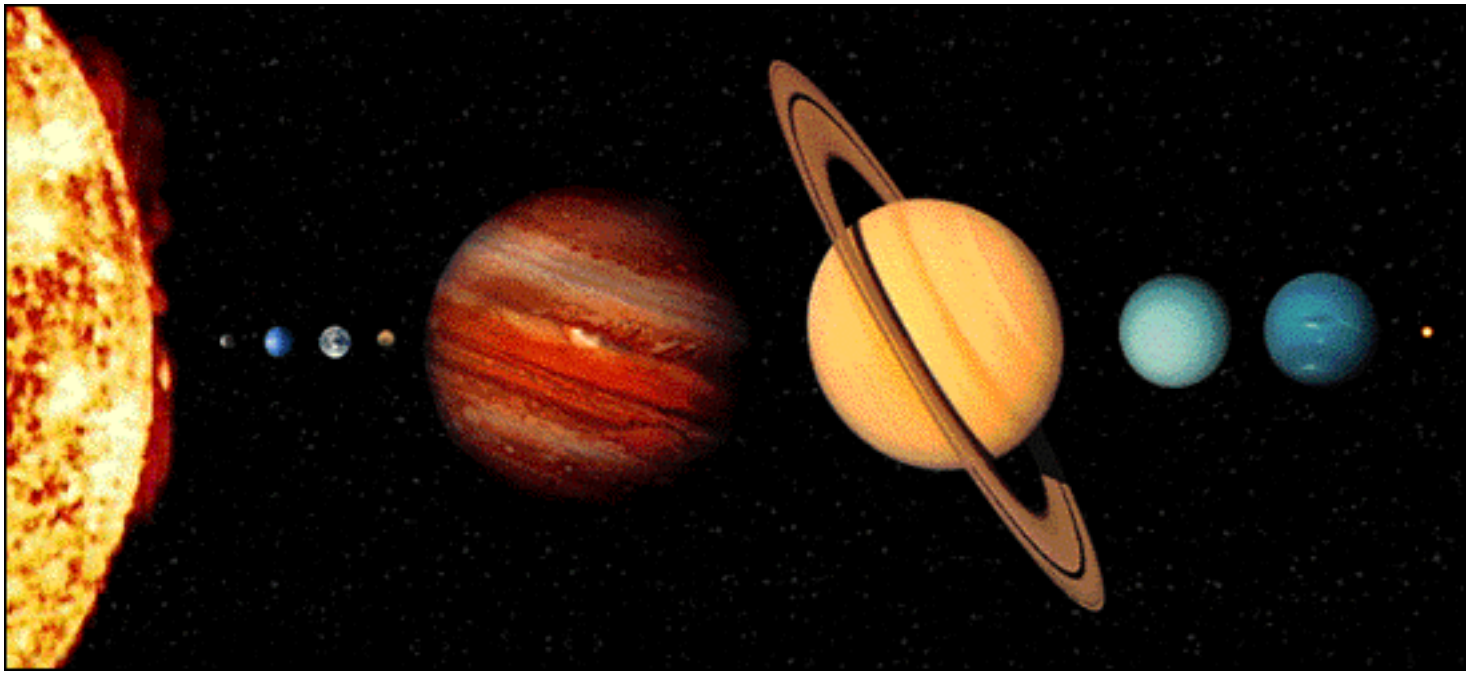
When a comet or asteroid swooped through the atmosphere and hit Earth, it created a huge crater. The crater is now buried beneath the southern part of Chesapeake Bay.

This crater is three times larger than any other in the United States. It is also the sixth largest in the world.

Craters on other planets are easier to see than the ones on Earth. So much of Earth is covered by water and vegetation that most of our craters are hidden.

Module 2, Investigation 2: Figure 1

The planets in our solar system

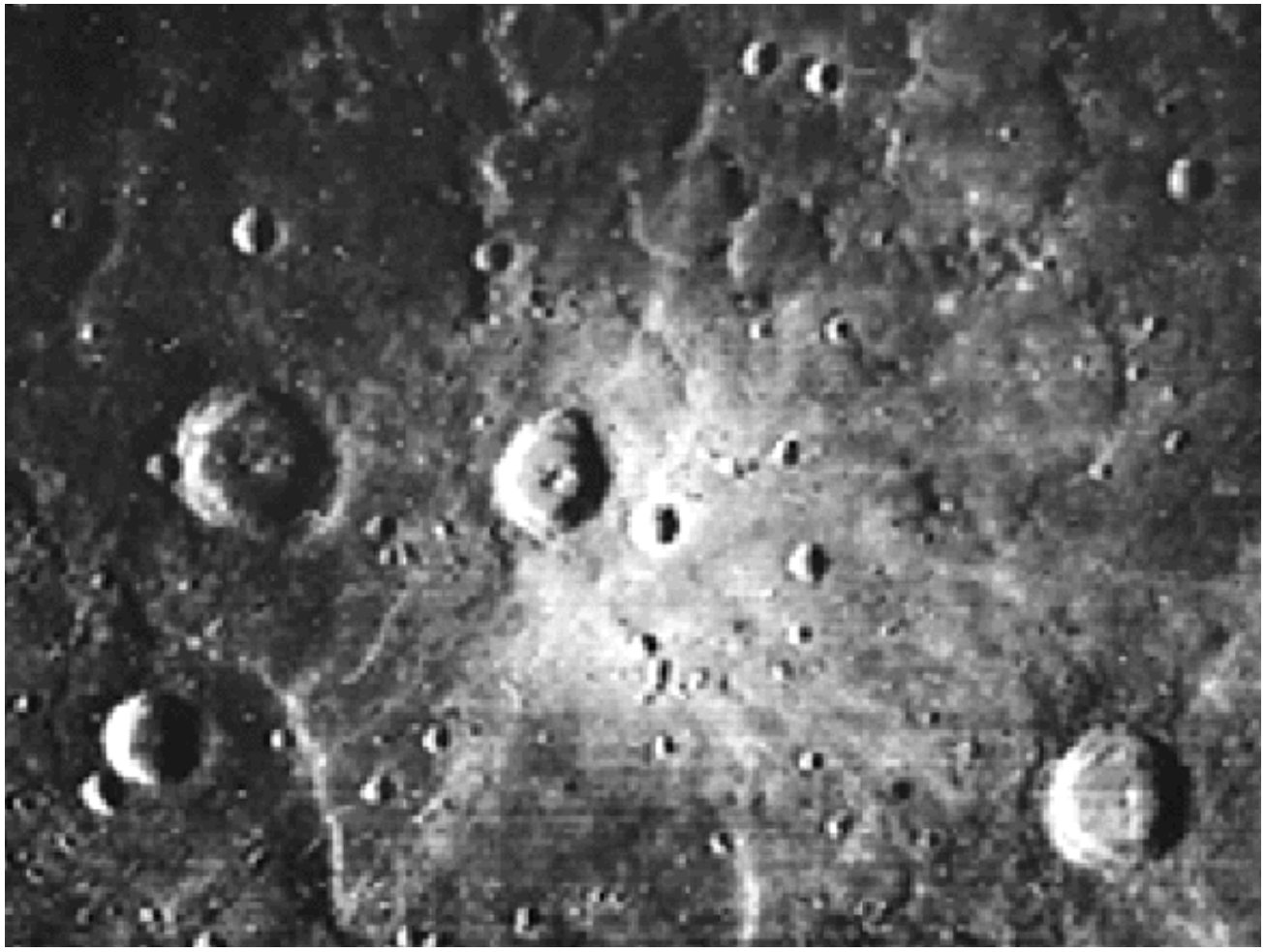


Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto

Source: http://pds.jpl.nasa.gov/planets/index.htm

Module 2, Investigation 2: Figure 2

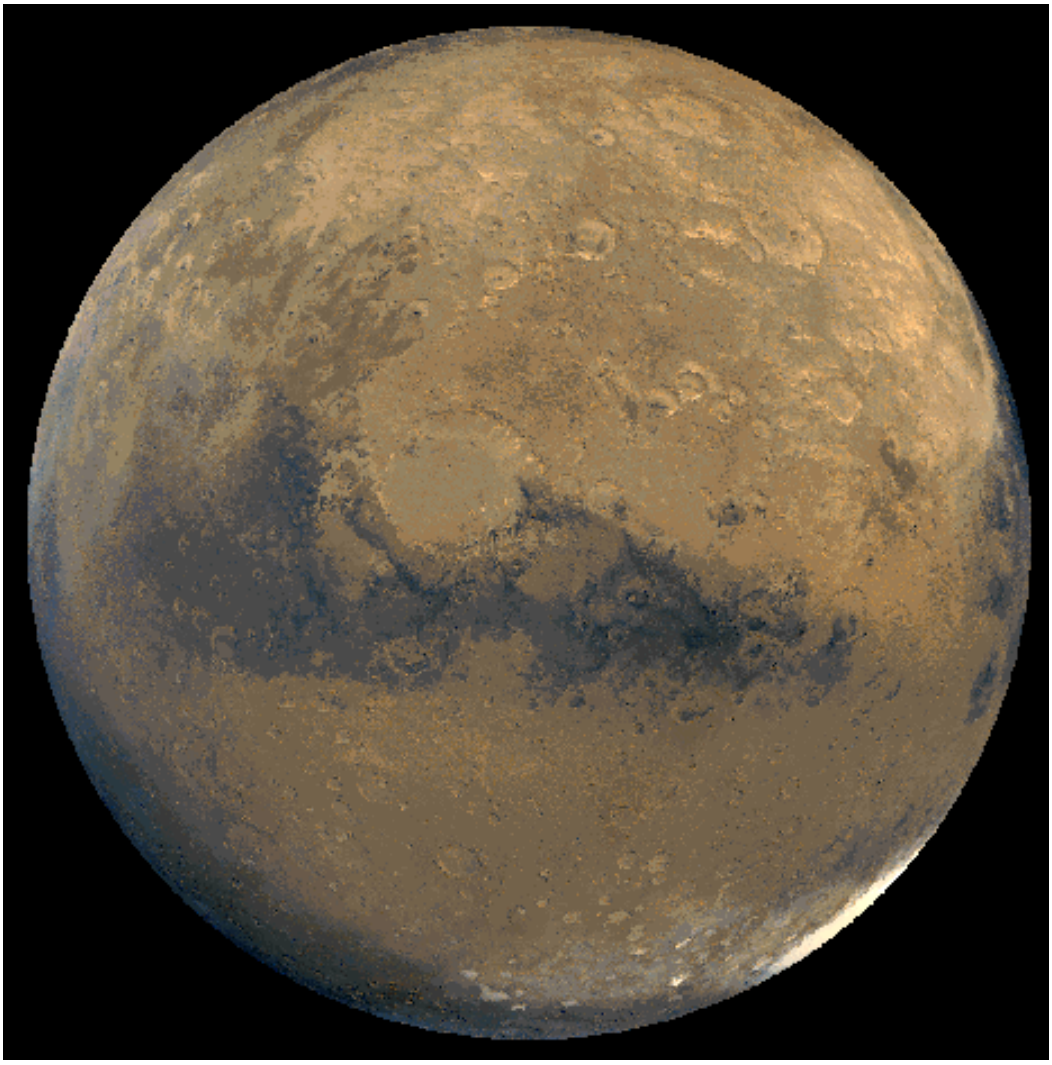
Craters on Mercury



Source: http://pds.jpl.nasa.gov/planets/gif/mer/mercury1.gif

Module 2, Investigation 2: Figure 3

Mars



Source: http://pds.jpl.nasa.gov/planets/gif/mar/schiap.gif

Module 2, Investigation 2: Figure 4

Earth

Source: http://www.fourmilab.ch/cgi-bin/uncgi/Earth

Module 2, Investigation 2: Figure 5

Chesapeake Bay

Hampton, Virginia is marked by the red dot.
Source: http://modis.gsfc.nasa.gov/MODIS/IMAGE_GALLERY/MODIS1000017_md.jpg

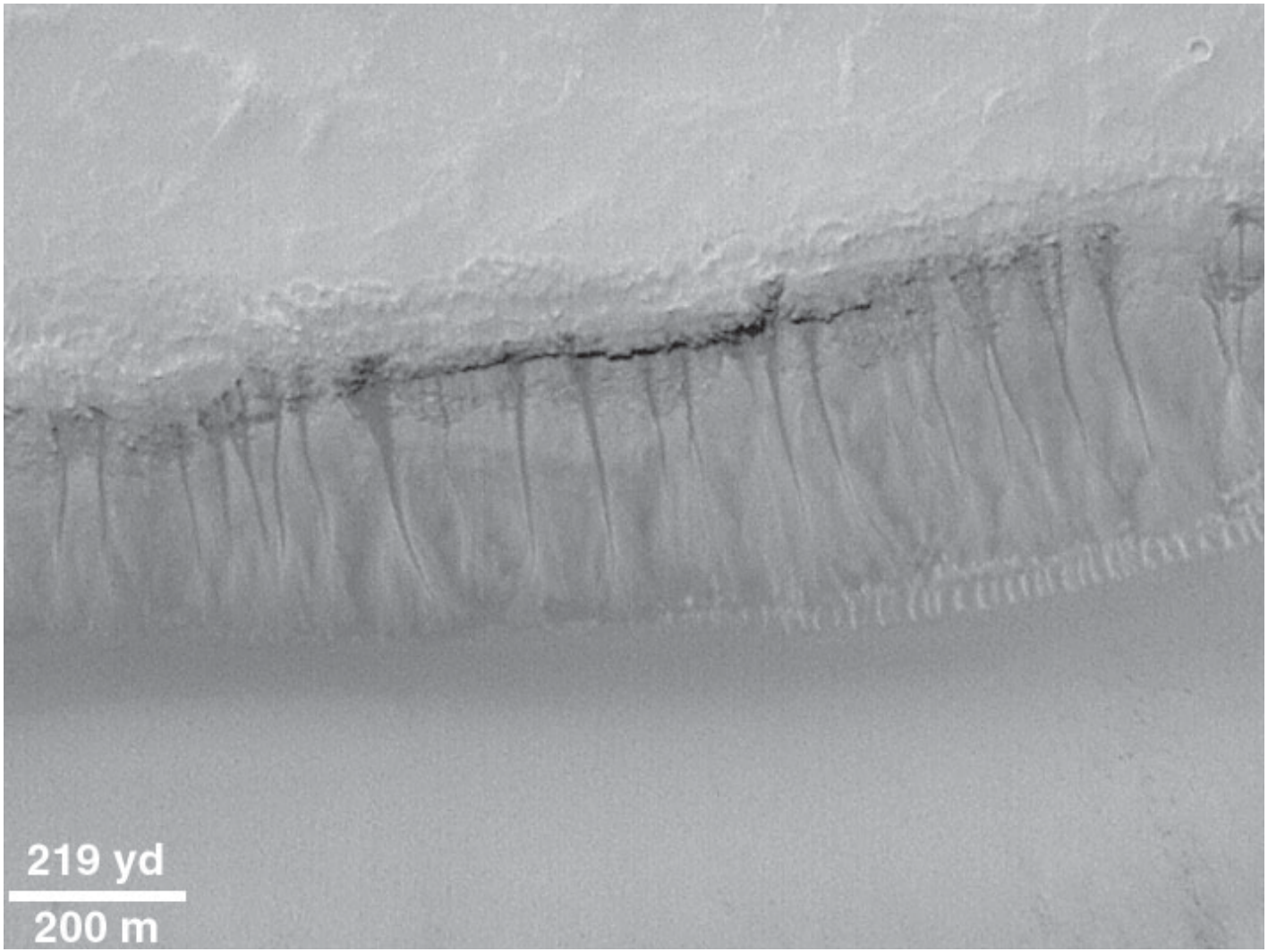
Module 2, Investigation 2: Figure 6

Mars in 1977

Source: http://www.msss.com/mars_images/moc/june2000/weeping/weeping_cntx_100.jpg

Module 2, Investigation 2: Figure 7

Mars in 2000



Source://www.msss.com/mars_images/moc/june2000/weeping/weeping_100.jpg